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Patentanmeldung Nr. Patent application No. Demande de brevet n°

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Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Inhibiting breakthrough of stimulation fluid via permeable geological layer into an oil production well

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INHIBITING BREAKTHROUGH OF STIMULATION FLUID VIA A PERMEABLE GEOLOGICAL LAYER INTO AN OIL PRODUCTION WELL

The invention relates to a method for inhibiting breakthrough of stimulation fluid via a relatively permeable geological layer into an oil production well. More particularly, the invention relates to a method for reducing the permeability of one or more relatively permeable geological layers of an oil field, which oil field comprises at least one oil producer well and at least one injector well. In a stratified oil bearing formation several oil bearing layers may be isolated by substantially impermeable layers, such as shale barriers.

When producing oil from an oil field, water and/or steam may be injected into the injector well to stimulate the production of oil. The oil is pressed by the water, steam, steam foam or froth and/or other stimulating fluid through the geological layers into the oil producer well, thereby enhancing the production of crude oil. Stimulation of oil production by injecting stimulating fluid into the formation is generally known as Enhanced Oil Recovery (EOR).

In a stratified oil bearing formation the permeability of different geological oil bearing layers may differ, which has as result that injected water will reach the producer well initially through the most permeable layer, before a substantial amount of the oil of the other, less permeable, layers is retrieved. This breakthrough of injection water is a big disadvantage, as the water oil ratio retrieved from the producer well will rapidly increase and become more and more unfavourable during the lifetime of the oil field.

It is known in the art to insert an annular plug in an inflow region of an oil production well to shut off the layer with the injection water break-through. Such an annular plug can be applied by locally providing a cement lining, which seals off the respective layer. It is however difficult to determine the position of this layer, such that generally several attempts have to be made before the flow of the layer is reduced. In some circumstances however the water producing layer cannot be identified and/or the placement of a cement plug cannot be performed.

It is therefore an object of the invention to provide a method, which alleviates the above mentioned disadvantages.

This object is achieved by a method according to the invention, which comprises the steps of:

- injecting a first compound into the injector well;
- detecting the first compound in the produced oil from the producer well;
- upon detection, injecting a second compound into the producer well to react with the first compound in order to provide a restriction in the geological layer generated by a third blocking compound which comprises a reaction product of the first and second compound.

As soon as the first, trigger, compound is detected in the water content of the produced oil, it is clear that an injection water break-through is present. By injecting a second, reactive, compound in the producer well, which will react with the first, trigger, compound, a seal can be provided solely in the area of the break-through.

This results in a very efficient seal, which does not influence the production of crude oil and associated natural water from the other layers.

Preferably the first, trigger, compound is inert relative to the compounds present in the oil field. This will provide for an optimal reaction with the second compound.

In a preferred embodiment of the method according to the invention the first, trigger, compound comprises an alkaline material and the second compound comprises iron chloride. This is a cost effective solution for a method according to the invention.

In another preferred embodiment the second compound further comprises hydrochloric acid, corrosion inhibitor and/or flocculent, such as a low molecular weight PAA or PHPAA.

In another embodiment of the method according to the invention the first, trigger, compound is encapsulated. This provides a solution for the case that the first compound reacts with compounds in the geological layers. The release of the first compound out of the capsule can be triggered by for example lowering the pH in the producer well. This reduction in pH could be the result of injecting the second compound.

The invention further relates to a kit of compounds for use in a method according to the invention, comprising a first, trigger, compound for injection into an injector well and a second reactive compound for injection in a producer well.

In figure 1 a schematic view of an oil field with several geological layers is shown, with which an embodiment of the method according to the invention is explained.

In the drawing a number of substantially impermeable shale layers 1 is shown with interposed three oil and formation water containing layers 2,3,4. The oil and water containing layers 2, 3 and 4 have different permeabilities. The intermediate oil and water containing

layer 3 has the highest permeability and the lowermost oil and water containing layer 4 has the lowest permeability. The pores of each layer 2, 3, 4 initially comprise oil (illustrates as -) and associated formation water 6 (H_2O, illustrated as ~) water.

Into the geological layers 1,2,3,4 an injector well 7 and an oil producer well 8 are arranged. Injection water to which a trigger chemical is added (illustrated as ~ + T) is injected into the injector well 7 and penetrates the different layers 2,3,4 and forms water flooded regions 9 (where the pores of the formation are substantially filled with injection water (~ + T). As a result of this water flooding process the oil 5 is pressed out of the layers 2,3,4 into the oil producer well 8.

In the permeable layer 3, the injection water (~ + T) has however reached the oil producer well 8.

According to an embodiment of the method according to the invention, break-through of this injection water and trigger chemical (~ + T) is detected by detection of any trigger chemical T in the produced well fluid stream 10. Suitable trigger chemicals T are alkaline materials such as NAOH, KOH and K2CO3. As soon as this trigger chemical T is detected in the producer well 8, production is stopped and a second reactive compound R is injected into the producer well 8. This second compound R, which could be for example iron chloride with some additional chemicals, penetrates from the producer well 8 into the geological layers 2,3,4. Upon contact with the first, trigger, compound T a chemical reaction T + R $\rightarrow$ B takes place resulting in a solid blocking compound B, which seals off the relevant layer 3 where breakthrough of injection water ~ + T has occurred. As the other layers 2 and 4 do not comprise the trigger chemical T in the region of the production well 8, there will not take

place any reaction between the natural formation water 6 and the second reactive compound R injected into the producer well. So the layers 2,4, which do not have a break-through of injection water ~ + T, will not be shut-off since no blocking compound B is formed in the pores of these layers 2, 4 in the vicinity of the inflow region of the oil producer well 8.

It will be understood that the injected water may be hot water and/or stream and that instead of injecting water other stimulating fluids, such as a froth, foam, carbon dioxide and/or nitrogen containing fluid may also be provided with a trigger chemical T which reacts with a reactive chemical R to provide a third blocking chemical B in those regions of an inflow zone of an oil production where a breakthrough of stimulating fluid occurs.

The method according to the invention is particularly attractive for inhibiting breakthrough of injection water via one or more relatively permeable oil bearing layers in a stratified oil bearing formation in which different oil bearing layers of different permeabilities are separated by substantially impermeable shale barriers.

C L A I M S

1. A method for selectively reducing the permeability of one or more relatively permeable geological layers of an oil field, to inhibit breakthrough of stimulating fluid from a stimulating fluid injector well via at least one of said layers into an oil producer well, which method comprises the steps of:
- injecting a stimulating fluid comprising a first compound into the injector well;
- detecting the first compound in the oil produced from the oil producer well;
- upon detection, injecting a second compound into the oil producer well to react with the first compound in order to provide a flow restriction generated by a third compound which comprises a reaction product of the first and second compound in at least one relatively permeable geological layer through which breakthrough of the stimulating fluid into the oil producer well has occurred.

2. The method according to claim 1, wherein the first compound is inert relative to the compounds present in the oil field.

3. The method according to claim 1 or 2, wherein the first compound comprises an alkaline material and the second compound comprises iron chloride.

4. The method according claim 3, wherein the second compound further comprises hydrochloric acid, corrosion inhibitor, and/or flocculent, such as a low molecular weight PAA or PHPAA.

5. The method according to any of the preceding claims, wherein the first compound is encapsulated.

6. The method of any preceding claim, wherein the oil field comprises various oil bearing layers having different permeabilities, which layers are separated by substantially impermeable layers, such as shale barriers and the method is applied to inhibit breakthrough of injection water into the production well via one or more relatively permeable oil bearing layers.

7. A kit of compounds for use in a method according to any of the preceding claims, comprising a first compound for injection into an injector well and a second compound for injection in a producer well.

8. The kit according to claim 7, wherein the first compound comprises an alkaline material and the second compound comprises iron chloride.

9. The kit according to claim 8, wherein the second compound further comprises hydrochloric acid, corrosion inhibitor, and/or flocculent, such as a low molecular weight PAA or PHPAA.

10. The kit according to any of the claims 7-9, wherein the first compound is encapsulated.

A B S T R A C T

INHIBITING BREAKTHROUGH OF STIMULATION FLUID VIA A PERMEABLE GEOLOGICAL LAYER INTO AN OIL PRODUCTION WELL

A method for selectively reducing the permeability of one or more geological oil bearing layers of an oil field to inhibit breakthrough of an injected stimulating fluid, such as water, via one or more relatively permeable oil bearing layers, comprises the steps of:

- injecting a stimulating fluid comprising a first, trigger, compound (T) into a injection well (7);
- detecting the first, trigger, compound (T) in the oil produced from an oil production well (8);
- upon detection of the trigger compound (T), injecting a second, reactive, compound (R) into the oil production well (8) to react with the trigger compound (T) in order to generate a third, blocking, compound (B) which creates a flow restricting barrier in the geological layer adjacent to the inflow region of the oil producer well.

The invention further relates to a kit of compounds for use in a method according to any of the preceding claims, comprising a first, trigger, compound (T) for injection into an injector well (7) and a second reactive compound (R) for injection in a producer well (8).

(Fig. 1)

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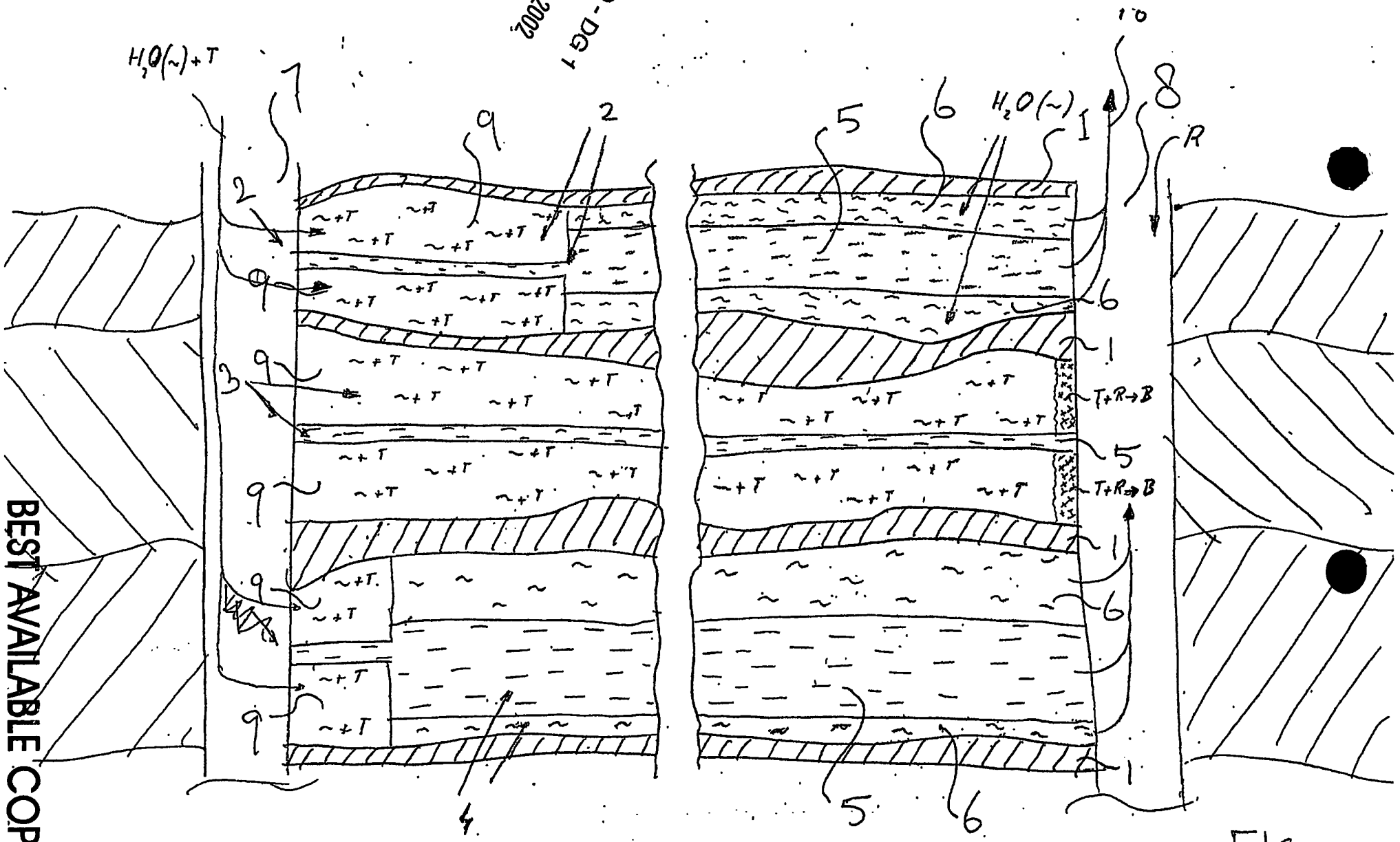

FIG.1